THE EFFECT OF CONCENTRATED SOLUTIONS OF CERTAIN MAGNESIUM SALTS ON PYOGENIC AND OTHER BACTERIA

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The feminine world for some time has known of and used a saturated solution of Epsom salt ($MgSO_4$) as a substitute for talcum or face powder. A small amount of the liquid is taken in the palm of the hand and rubbed gently all over the face until dry, thus leaving a soft "bloom" on the skin.

Those who were inclined to have pimples found that the use of Epsom salt had a salutary effect on the skin, the pimples drying up and disappearing. This knowledge has not been known to the writer alone. A prominent eye, ear, nose and throat specialist stated that he had gained quite a reputation as a skin specialist from suggesting this treatment after having observed its beneficial effects in several instances.

This seemingly specific action led the writer to investigate the influence of magnesium sulphate on the organism commonly found in ordinary pimples, Staphylococcus aureus.

The procedure for the phenol coefficient of $MgSO_4$ was carried out for Staphylococcus aureus, and also for B. typhosus with the following results:

TABLE 1

STAPHYLOCOCCUS AUREUS

Strength		Time in Minutes					
Per Cent.	Dilution	2.5	5	7.5	10	12.5	15
Phenol 5.0	1:10	—	—	—	—	—	—
Phenol 2.5	1:40	—	—	—	—	—	—
Phenol 1.0	1:100	+	+	+	+	+	+
Phenol 0.5	1:200	+	+	+	+	+	+
$MgSO_4$ 50*	1:2	+	+	+	+	+	+
$MgSO_4$ 25	1:4	+	+	+	+	+	+
$MgSO_4$ 12.5	1:8	+	+	+	+	+	+
$MgSO_4$ 5	1:20	+	+	+	+	+	+

* Practically saturation. 50 gm. $MgSO_4$ were made up to 100 c c with distilled water at 25 C.

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TABLE 2

B. TYPHOSUS

Strength		Time in Minutes					
Per Cent.	Dilution	2.5	5	7.5	10	12.5	15
Phenol 5.0	1:20	—	—	—	—	—	—
Phenol 2.5	1:40	—	—	—	—	—	—
Phenol 1.25*	1:80	—	—	—	—	—	—
Phenol 1 1/9*	1:90	+	—	—	—	—	—
Phenol 1.0	1:100	+	+	—	—	—	—
Phenol 0.5	1:200	+	+	+	+	+	+
$MgSO_4$ 50	1:2	+	+	+	+	+	+
$MgSO_4$ 25	1:4	+	+	+	+	+	+
$MgSO_4$ 12.5	1:8	+	+	+	+	+	+
$MgSO_4$ 5	1:10	+	+	+	+	+	+

* Data for percentages 1.25% and 1 1/9% phenol were obtained from Hyg. Lab. Bul. 82, 1912, U. S. Public Health and Marine Hospital Service.

These results were so unexpected and also so convincing that the experiment of growing Staphylococcus aureus in the presence of different percentages of $MgSO_4$ in broth was next tried.

Two hundred and fifty mm. of $MgSO_4$ were made up to 500 c c with nutrient broth and percentages from 50% ranging by a difference of 5%, down to 5% were prepared, filtered and autoclaved. These tubes were then each inoculated with a loopful from a broth culture of Staphylococcus aureus and incubated at 37 C. Table 3 shows the results.

TABLE 3

STAPHYLOCOCCUS AUREUS

Age	Per Cent. of $MgSO_4$ in Broth										
	5	10	15	20	25	30	35	40	45	50	
24 hours	+	+	+	+	?	?	—	—	—	—	Macroscopic exam.
		Not necessary			+*	+	+	+	+	+	Microscopic exam.
48 hours	+	+	+	+	+	+	+	+	+	+	Macroscopic exam.
		Not necessary			+	+	+	+	+	+	Growth in broth transfers made from 25-50% $MgSO_4$ broth cultures

* At the end of 24 hours, from the 25% on up to 50% $MgSO_4$ cultures, transfers were made into ordinary broth to see if S. aureus was still alive. (Results in last horizontal row of the table.) It was noted that 5-25% $MgSO_4$ broth showed typical heavy turbidity and ring formation while from 30 up to 50% a decided pellicle was formed, with less turbidity. The pellicle was heaviest on 25, 40 and 45% $MgSO_4$ broth. Beauverie noted a similar phenomenon when growing the cholera organism in broths containing from 0.5-3% NaCl. A thicker and firmer velum was produced in the salt concentrations up to 3%.

The conclusion, then, is that the beneficial effect of a saturated solution of $MgSO_4$ on the skin is not due to any action on this particular organism.

The same concentrations of $MgSO_4$ in broth were inoculated with Streptococcus pyogenes, B. typhosus and B. coli — the first organism to see whether streptococcus skin infections might not be held in check by the salt, the second two organisms to ascertain whether the salt has any effect on the growth of organisms found in the intestine.

TABLE 4

EXPERIMENTS WITH DIFFERENT ORGANISMS

Organisms	Per Cent. of $MgSO_4$ in Broth										
	5	10	15	20	25	30	35	40	45	50	
Streptococcus pyogenes.	—	—	—	—	—	—	—	—	—	—*	$MgSO_4$ broth Nothing visible macroscopically in plain broth
B. coli.....	+ +	+ +	+ +	+ +	+ +	? —	? —	? —	? —	?* —	$MgSO_4$ broth Plain broth
B. typhosus.....	+ +	+ +	+ +	+ +	+ +	? +	? —	? —	? —	?* —	$MgSO_4$ broth Plain broth

* Four days after inoculation (1st 2 days at 37 C., last 2 at room temperature). At this time loop inoculations were made from each tube into broth to see if the organism can stand the various concentrations for any length of time. Broth tubes were incubated at 37 C. Results are given for each organism in the second rows above.

Loop inoculations were made from the highest concentration of $MgSO_4$ broth that shows growth into the remaining concentrations to see whether each may become acclimatized. All of the streptococcus cultures were reinoculated.

TABLE 5

REINOCULATIONS

Organisms	Per Cent. $MgSO_4$ in Broth										
	5	10	15	20	25	30	35	40	45	50	
Streptococcus pyogenes.....	All negative										$MgSO_4$ broth Plain broth
B. coli.....	.. —	.. —	.. —	.. —	* —	.. +	.. —	.. —	.. —	.. —	$MgSO_4$ broth Plain broth
B. typhosus.....	.. —	.. —	.. —	.. —	.. —	* —	.. +	.. —	.. —	.. +	$MgSO_4$ broth Plain broth

* Concentrations above this were inoculated with a loopful from this concentration and incubated at 37 C. for 24 hours, reinoculated into plain broth and placed again at 37 C. for another 24 hours. Reinoculation into broth is necessary as the higher concentrations of $MgSO_4$ broth are too cloudy to determine growth macroscopically.

This seems to indicate that streptococcus skin infections may be inhibited if any concentration of $MgSO_4$ be used externally.

To determine whether $MgSO_4$ in a strength above saturation has a plasmolyzing effect on Staphylococcus aureus, several clean coverglasses were split with a red hot wire, flame-sterilized and placed in a

sterile petri dish. Then 50% $MgSO_4$ broth was heavily inoculated and a loopful placed on each piece of cover-glass which was put at 37 C. to dry. This took from 6-8 hours. At this time each piece was transferred to a tube of broth and incubated at 37 C.

Of the 8 tubes of broth prepared in this way 2 showed heavy growth in 24 hours, and the remaining 6 showed moderate growth as determined by turbidity. This excludes plasmolysis as a factor in the destruction of Staphylococcus aureus.

TABLE 6

$Mg(NO_3)_2$

Organisms	Per Cent. of $Mg(NO_3)_2$										Hrs.
	5	10	15	20	25	30	35	40	45	50	
First Trial											
Staph. aureus.....	+	+—	—	—	—	—	—	—	—	—	24
	+	+	+—	—	—	—	—	—	—	—	48
B. coli.....	+	+—*	+—*	+—*	+—*	+—*	+—*	+—*	+—*	+—*	24
	+	+—	+—	+—	—	—	—	—	—	—	48
Strept. salivarius...	+—*	+—*	?	—	—	—	—	—	—	—	24
	?	?	—	—	—	—	—	—	—	—	48
B. typhosus.....	+—*	—	—	—	—	—	—	—	—	—	24
	same	—	—	—	—	—	—	—	—	—	48
Second Trial											
Staph. aureus.....	+	+	*	—	—	—	—	—	—	—	24
	+	+	+	—	—	—	—	—	—	—	48
B. coli.....	+	+	*	*	*	*	*	—	—	—	24
	+	+*	+	+	—	—	—	—	—	—	48
B. typhosus.....	+	*	*	*	*	—	—	—	—	—	24
	—	—	—	—	—	—	—	—	—	—	48
Ps. pyocyanea.....	+	*	*	*	*	*	*	*	—	—	24
	+*	*	*	*	*	+	+	—	—	—	48

Explanations: In Tables 6, 7 and 8 + = cloudy liquid, growth present; — = clear liquid, no growth present.

* Not cloudy—viscous or flocculent sediment comes up with a swirl on rotating the tube sharply.

The action of $MgSO_4$ on common pimples can hardly be explained by its physiologic action, as it has only a sedative or local anesthetic influence which is due to its depressing action on the sensory nerve endings.

Morison and Tulloch's[1] work on the treatment of war wounds with magnesium sulphate seems to indicate that this salt has bactericidal properties. They state as follows:

[1] Jour. Roy. Army Med. Corps, 1916, 27, p. 375.

It possesses the desirable property of interfering with the digestive activity of pus. . . . Magnesium sulfate has not so markedly inhibitory action on phagocytosis as one would expect, and therefore, even if it be absorbed to a slight extent, it would not have a deleterious influence on the process. . . . The magnesium ion has a markedly inhibitory action on the growth of streptococci and B. coli, and a slightly inhibitory effect on the growth of B. pyocyaneus. It has, however, no easily demonstrable influence in the concentrations examined on the growth of staphylococci, nor on the diphtheroids investigated.

Similar experiments were carried out with other soluble magnesium salts $Mg(NO_3)_2$, $MgCl_2$ as well as $MgSO_4$, in order to determine whether the Mg ion itself is responsible for the action observed or whether this particular combination of ions is necessary. Tables 6, 7 and 8 show that the latter hypothesis is probably correct:

TABLE 7

$MgCl_2$

Organisms	Per Cent. of $MgCl_2$												
	5⅓	10⅔	16⅓	21⅓	26⅔	32	37⅓	42⅔	48	53⅓	58⅔	66⅔	
Staphylococcus aureus	+	+	+	+	+*	+*	+*	−	−	−	−	−	24 hours
	+	+	+	+	+	+	+	−	−	−	−	−	48 hours
B. coli	+	+*	−	−	−	−	−	−	−	−	−	−	24 hours
	+	+	−	−	−	−	−	−	−	−	−	−	48 hours
B. typhosus	+	−	−	−	−	−	−	−	−	−	−	−	24 hours
	+	−	−	−	−	−	−	−	−	−	−	−	48 hours
Ps. pyocyanea	+	−	−	−	−	−	−	−	−	−	−	−	24 hours
	+	−	−	−	−	−	−	−	−	−	−	−	48 hours

TABLE 8

$MgSO_4$

Organisms	Per Cent. of $MgSO_4$										
	5	10	15	20	25	30	35	40	45	50	
Staphylococcus aureus	+	+	+	+	+	+	+	+	+	+	24 hours
	+	+	+	+	+	+	+	+	+	+	48 hours
B. coli	+	+	+	+	+	+	+	+	−	−	24 hours
	+	+	+	+	+	+	−	−	−	−	48 hours
Ps. pyocyanea	+	+	+	+	+	+	+	+	+	−	24 hours
	+	+	+	+	+	+	+	+	+	−	48 hours
B. typhosus	+	*	+	*	+	*	−	−	−	−	24 hours
	+	+	+	+	+	−	−	−	−	−	48 hours

The results of Morison and Tulloch with regard to S. pyogenes were proven in the use of $MgSO_4$, but not in case of B. coli; $MgCl_2$ was the only magnesium salt used that had an inhibitory action. In

fact, this latter salt had the most marked inhibitory action on the growth of all organisms used in the experiment. This suggests that a substitution of $MgCl_2$ for $MgSO_4$ might have the advantage under certain conditions.

Further study of the specific action of concentrated solutions of $MgSO_4$ and other magnesium salts on the infected skin or in wounds may present interesting if not valuable information.